Review of runoff forestry in Shanxi Province and sustainable development tactics of forestry

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Abstract: Through more than one month of investigation on runoff forestry in Luliang mountainous areas of Shanxi Province, the runoff forestry techniques were regarded as having a popularized value in arid and semi-arid areas. The development of runoff forestry in Shanxi Province was summarized and the sustainable development tactics was put forward.

Key words: Semi-arid areas; Runoff forestry; Sustainable development; Development tactics
CLC number: S715.7; S728 **Document code:** B **Article ID:**1007-662X(2000)02-0135-05

Introduction

In arid and semi-arid areas, shortage of water resources was a major factor limiting sustainable development of agriculture, forestry and animal husbandry. It related directly with local the ecological forestry and the social/economic development. In Shanxi Province, the mountainous areas holds abundant land, light and heat resources, but these original resources superiority can not be used effectively by plant community because of a long-term suffering from air or soil drought and water shortage. Especially, because of the destroy activities on forestry in the history, the indiscriminate felling of the trees, the excessive land-reclamation and extensive management in recent years, the local forest cover was seriously damaged and the forest coverage sharply declined. This plunder type of productive social activities resulted in a vicious circle of ecological system in some areas, the ecological balance was very fragile there. In order to resolve the problem of ecological environment deterioration and change the poor and backward state of mountainous areas, "Five Projects" and a "Fight Target" was laid out by Shanxi Provincial Party Committee and Provincial government. To the end of 1998, per-capita cash forest area would reach 0.667 hm^2, per-capita income reach 1,000 yuan in countryside, and the whole Province would be basically green, which embodies unshakable conviction of the Party and the Government to get Party and the Government to get rid of the poverty. After long-term productive practice to fight against drought and the popularization of scientific achievements, the people are lastly aware of importance of popularization of the water collecting technique of runoff forestry in improving ecological environment and getting rid of poverty. The runoff forestry technique is a great achievement in fighting against drought, and it would make a due contribution to development of the forestry in arid areas.

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Received date: 2000-03-24
Responsible editor: Song Funan

Background of emergence of the runoff forestry

Affected by general circulation and be short of ecological regulation of forest resources, the incidence of drought and flood in Shanxi Province became higher and higher, the climate was quickly deteriorated. The annual precipitation of the Province is 400-500 mm, 60% of which falls in July to September and often accompanied by rainstorms. The climate was characterized by 'nine drought years out of ten and either drought or waterlogged". According to records of historical data, 306 times of drought occurred during 500 years from 1 460 to 1980, that is, drought occurred every 1.7 years.

Located in Loess Plateau, the landform of Shanxi Province is characterized by loess hills and gullies. Since the loess is easy to cut by water, the runoff produced in rainstorm stage would be collected to mud-sand flow and resulted in damage. The Yellow reiver Valley by Luliang Mountain was one of the most serious soil and areas of China. For the whole Province, the soil and water loss area was 108 000 km^2, of which 67 600 km^2 was in Huanghe Valley of

Northwest Shanxi province. The annual volume of mud and sand imported to Huanghe was 45 600 000 t, the quantity of N, P and K lost from mud and sand was about 5 000 000 t, correspondent to total of the chemical fertilizers of the whole Province annually applied to farmland (The special soil and water conservation planning group of Shanxi Province 1987). The disastrous soil and water erosion had resulted in the thinning of soil layer of farmland, dropping of soil fertility, raising of riverbed, sedimentation of reservoirs, decrease of agricultural output, imbalance of ecology, and poverty of monotonous areas. From these bitter experiences, the people gradually understand that the ecological crises caused by drought and soil and water erosion are threatening the basic living conditions and the social progress of the mankind.

Forest was not only an important resource in economic development of a society, but also an irreplaceable object to maintain terrestrial ecological balance. It played a very important ecological regulation role in formation of a good local climatic environment and geographic landscape. There are three measures to restore the vegetation and to increase the percentage of the forest coverage: close hillsides to facilitate afforestation, sow tree seeds from the air by plane, and conduct artificial afforestation. Close hillsides to facilitate afforestation and the aerial seeding are characterized by quick speed, less cost and save of both labor and time, but in arid areas, their effects are not so obvious. Shanxi Province has invested a large amount of money in afforestation annually, only from 1975 to 1993, the accumulated afforested area had reached 4 370 000 hm^2. But because of various objective reasons, the survival rate of afforestation continuously wandered about at 30%, and the percentage of the forest coverage was only 20.1%. As a result, the forestry developed very slowly. The traditional mode of forestry characterized by extensive management was already far beyond to meet the requirement of the sustainable forestry development.

Review of the runoff forestry

Runoff water collecting has a long history in China. As far back as 4 000 years, Tianchuan method had already been used for cultivation. The Tianchuan method means ditching in mountain slopes along the contour (33 cm wide and 33 cm deep ditches) and using retained rainwater for improving crop's output. In the Southern Song Dynasty, three kinds of cultivating methods were created, constructing terrace over high mountains, ditching pits over fields and cultivating crops along field ditches, for retaining of runoff, too. In afforestation of arid areas, runoff collecting has also a long history, but at first the runoff collecting method was copied from the agricultural production. After founding of new China, a lot of soil preparation methods of suitable for forestry were created, such as fish-scale pits, counter-slope terrace, horizontal terrace, etc. These soil preparation methods could retain certain runoff in high flow year, but couldn't collect much water in low flow year. Therefore, these passive water-collecting methods couldn't meet the needs of afforestation for soil water.

Taking the runoff forestry as a special technique to study was only an event in recent 10 years, which poured the powerful vitality into the drought relief afforestation. To summarize achievements of runoff forestry, taking the major technical events as marks the development of it in Shanxi Province was divided into two stages: searching stage and preliminary developed stage.

Searching stage

Three years from 1986 to 1988 was included in the stage. In 1986, on the bases of summary and study of drought-relief afforestation techniques of our predecessors, Professor Wang Binrui of Beijing Forestry University first put forward to the concept of the runoff forestry and given a scientific meaning to it. The runoff forestry was brought into the orbit of science (Wang 1993). The kernel of the runoff forestry was through artificial regulative measures to create a suitable water environment so as to make survive and growth of seedling reach a best state. In many year's research and tests made in Fangshan County, the initiative water collecting measures were adopted and a good results was attained, the used impervious materials included plastic film, asphalt and high-molecular impervious agents. But because of high cost, these measures could be only used in high-yield orchard. The test forest established by Shanxi Forestry Institute in Daning County, using preparation method of making ditches over slopes and tamping down slope's surface for planting of poplar, paulownia and walnut, achieved great success in 1988 (Yang 1991). A batch of important results was attained during the stage, which had laid a firm scientific basis for popularization and application of runoff forestry in forest management and forestry production.

Preliminary developed stage

From emergence of the preparation method by making ditches over slopes and tamping down slope's surface in 1988 to large-scale popularization of it in Luliang Prefecture in 1995, the seven years was included in the stage. The Luliang Prefecture was one of the areas to popularize

the achievement earlier; Fangshan, Shilou and Lishi counties were involved in. In addition, Xixian, Daning and Jixian counties of Linfen Prefecture and Changzhi, Pingshun and Huguan counties in Northeast the Province were also included; the popularized area reached 500 000 hm^2. The features of the stage were the first combination of runoff forestry with forest management and forestry production and the enrichment of soil preparation method and afforested tree species.

In popularization works, except the method by making ditches over slopes and tamping down slope's surface was widely used, a lot of other soil preparation methods were also created by the people, such as pits like "回", horizontal ditches, pits like "V", and other initiative water collecting methods. At meantime, the cultivating mode with single species was changed; selection and arrangement of tree species were given great attention. The major tree species selected by these areas according to respective traditional superiority and special resources were as follows: commercial tree species--*Populous tomentosa, P. bolleana, P. beijingensis, paulownia, elm, Robinia pseudo-acaccia, Pinus tabulaeformis, Platycladus orientalis,* etc; cash forest tree species--apricot, date, walnut, apple, pear, Chinese Hawthorn, *Bunge Pricklyash*, etc; water conservation tree species--*Caragana korshinskii, Tamarix chinensis, Amorpha fruticosa,* etc; and green tree species in Hukou Waterfall tourist spot of Jixian County---*Platycladus orientalis, Salix matzudana, Hippophae rhamnoides, Sorbaria sorbifolia,* torch tree, etc..

Benefits of runoff forestry

Productive benefits

Referring to the contents of soil water and soil organic matter, the precipitation in Fangshan County from April to October was only 331.6 mm. Compared with that of the natural slope, the water in forest belt could be increased by 387.7 mm/hm^2 by tamping down the slope's surface, that is to say, a total of 715.3 mm of water could be retained during the growing season, correspondent to the precipitation of coastal areas of China over the same period; the analysis of soil nutrients of horizontal ditches with tamping down slope's surface in Daning County showed that it's organic matter content (1%) was 46% higher than that of the natural slope farmland, Nitrogen content was increased by 77%, and other soil nutrients content were also obviously raised(Yang 1991).

Referring to survival rate of afforestation, the survival rate of *Pinus tabulaeformis* planted in horizontal ditches with tamping down slope's surface reached 95%, which is 46% higher than that of control.

Referring to growth and fruit bearing of trees, the average tree height of poplar and paulownia were 6.7 m, 52.2% higher than that of control, the average breast-height diameter of them were 7.6 m, 46.1% higher than that of the control. In 1991, the Shilou County established a date orchard, some trees bore fruits at the same year and all trees bore fruits in 1992. The output of fresh date in 1993 reached 3 000-3 750 kg/hm^2, 4.15 times that of the ordinary date orchard (Lu 1992). In Pingshun and Fangshan counties, where the runoff forestry was adopted, the apricot trees bore fruits in the third year and entered the first stage of fruit bearing in the fifth year, and the annual output of dry apricot kernel was up to 450 kg/hm^2 in the eighth year.

Economic benefits

With application of the runoff forestry, the income of mine timber from 6 years old robinia forest could be up to 1 260 yuan/hm^2. When using traditional afforestation methods, it needs 15 years for reaching the standard making mine timber, the volume of wood per hm^2 is below the level when using runoff forestry, too.

With application of the runoff forestry, the annual output value of apricose could be up to 18 000 yuan/hm^2, 5 250 yuan more than that of the ordinary orchard; the annual output value of the date orchard was up to 22 500 yuan/hm^2, 8 900 yuan higher than that of the ordinary orchard; and the annual output value of the apple orchard was 18 720 yuan/hm^2, 6 450 yuan more than that of the ordinary apple orchard.

Ecological benefits

In arid loess hills areas, the rainwater retained by runoff collecting forest fields could be reached 675-900 t/km^2 annually, equals to an increase of 300-500 mm rainfall; the topsoil loss was reduced by 40.95-118.35 m^3/km^2 on the average, equals to an increase of 0.1--0.3 cm depth of soil layer. There are 145.75 million hm^2 of slope farmland in Shanxi Province. When 30% of them is returned to forestry and afforested using runoff forestry techniques, an amount of 295.143 million-393.525 million t of runoff water would be retained annually, the loss of mud and sand would be reduced by 17.905 million-51.749 million m^3.

Social benefits

The runoff forestry provided the ecological forest engineering with a batch of suited key techniques directly. In Fangshan, Shilou, Xixian, Jixian and Daning counties, the runoff forestry technique has already been used in construction of forest engineering.

Through selection of cash forest tree species, the runoff forestry was closely related with the control of poverty of farmers, the fruit processing and the wood processing industries would become support industries of local area and would promote the fast development of the social economy.

Sustainable development of forestry

The runoff forestry was a leap in sustainable development of forestry and was hard to avoid difficulties and problems in its development. For example, the engineering quality in some areas was unable to through the shock of the largest rainfall for 24 h, which met every 10 years; being short of scientificity, some engineering were not constructed on the basis of scientific norms, and didn't insist in the principle of planting proper trees in proper sites, the selection of the tree species had certain blindness; the policy which favor investment was not really put into effect yet, the funds was short of requirements and not fully supplied. All above reasons affected the progress of engineering. In view of the problems encountered in popularization of the runoff forestry, we must make out relevant tactics to ensure the runoff forestry enter upon a full development stage.

Deepening understanding

Deepening the understanding of cadres and masses on runoff forestry is a precondition for transition of forestry conception. Referring to the drought-relief afforestation, the runoff forestry was a beginning of transition from traditional forestry to modern forestry. The old conception of extensive management and the short-term action of resources exhaustion must be changed to intensive, large-scale, using improved varieties and commercialized management, and treated the forestry with a strategic foresight of sustainable development. This is just the understanding basis of speeding up the increase of forest resources, improving ecological environment and promoting social progress.

Doing well in scientific planning

Further deepening of the runoff forestry techniques should be transplanted in the protective forest ecosystem. It should carry out a comprehensive treatment and avoid of one-sidedness in construction of engineering, and make plan for farmland, water conservation land, grazing land and forestland scientifically. By dealing with the internal relationship within the large-scale agriculture properly, the consciousness of returning grain plots to forestry should be intensified. Referring to forestland, the site-type classification and the selection of suitable tree species should be done well to give full play of production potentialities of forestland and forest trees (Li 1994).

Strengthening government action

The government should draw up relevant mating policies on runoff forestry as quickly as possible and through administrative means execute the target afforestation responsibility system in one's official term of leading cadres. The afforestation tasks should be analyzed on shoulders of all leading cadres at all levels. At the same time, the investment in industry and agriculture should favor in poor mountainous areas; the investment proportion in large-scale agriculture should be increased, especially in ecological forest engineering and scientific research.

Readjusting phasic policies

With establishment of the socialist market system, the old forestry policy already can not resolve the distribution problems of profits of public forests, taking ecological benefits as it's major aims, and the investment problems in development of the runoff forestry. So, the economic policies should be readjusted in time to suit this change. The kernel of the policies should be to set up a compensation system for ecological benefits (Shi 1995). The ecological benefits of the runoff forestry is a condensation of social necessary labor, it has not only a usable value but also a social value. Therefore, it should impose compensation fees for expansion reproduction of the runoff forestry.

Readjusting structure of the forestry and fruit trees

Faced with challenge of the market system, the construction of the ecological engineering in development of the runoff forestry should be done well, at the same time, the special resource superiority of the constructed areas should be brought into full play. Taking market as guide and on the basis of scientific planning, the forestry and the fruit trees should be large-scale developed to accelerate the development of commercial forestry economy. It should not only readjust developing proportions within forestry and fruit trees properly, but also correctly deal with the economic structure of forest, fruit, wood and their processing.

Increasing scientific content of engineering

The runoff forestry will promote overall successive development of the forestry, the popularization of the runoff forestry techniques need to follow the step of "first easy then difficult, from near to distant". Meanwhile, with continuous deep-going of development of

modern forestry, the problems encountered must be more and more and the degree of difficulty must also be higher and higher. So, it must depend on progress of science and technology to promote the construction step of the forestry. Referring to funds for scientific research, the investment proportion in runoff forestry should be raised. The scientific research funds should be operated with investment of the key ecological forest engineering in synchronism to increase the scientific content of them and to enable the runoff forestry giving better service to construction of the ecological forest engineering.

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